



Overview

- Background
- Customer Requirements
- Functional Requirements Summary
- Demo Features/Capabilities
- SAFFE System Behaviors
- SAFFE Stand-Alone Demo Architecture
- CHI/Display Introduction
- SAFFE Demonstration Scenarios

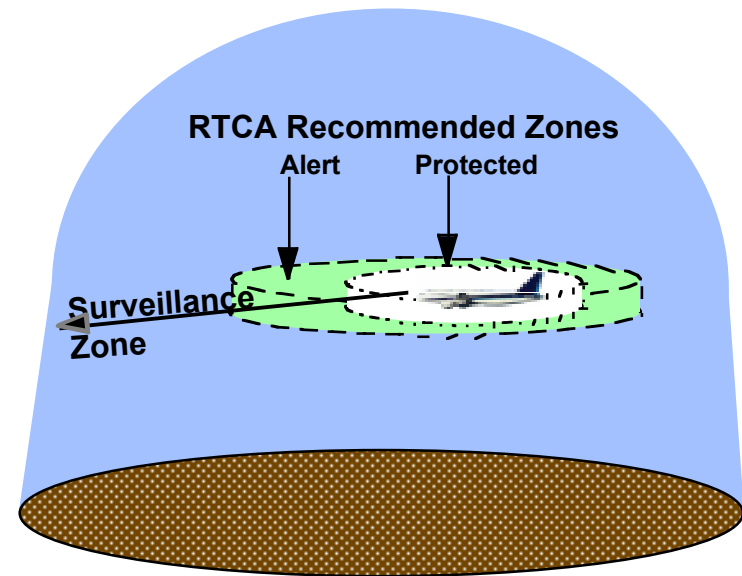
Background

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Definitions

- Separation Zones
 - Protected Zone (PZ) - 2.5 Mi
 - Alert Zone (AZ) - 2-3 min.
 - Look Ahead Zone (LAZ) - 6-15 min.
 - Surveillance Zone (SZ) - communication range
- Equipage
 - Independent FD
 - Dependent FD (receive & view traffic, data link ATSP route plans and plan acceptance)
 - Basic FD (minimum equipment is ADS-B beacon)
- Flight Plans
 - Operational Flight Profile (OFP)
 - Preliminary Flight Profile (PFP)



Customer Requirements

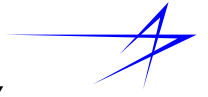
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- Primary objectives of the SAFFE software:
 - Conflict detection within a 6 -15 minute time horizon
 - Conflict resolution with corresponding procedures and computer-human interface (CHI)
 - Meeting Required Time of Arrival (RTA) with 4-D conflict-free resolutions (multiple A/C conflicts only, not for weather and SUA)
 - Meeting RTA with 4-D conflict-free resolutions while performing optimal descents
- Lockheed Martin deliverables:
 - Software Requirements Document (SRD)
 - User Instruction Manual (UIM)
 - SAFFE Software

FD/ATSP Functional Requirements Summary

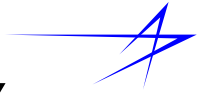
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- Detect mergers between aircraft Protected Zones and:
 - Other aircraft Protected Zones (all equipage levels)
 - Special Use Airspace (SUA)
 - Hazardous weather
- Detect mergers between aircraft Alert Zones and:
 - Other aircraft Alert Zones (all equipage levels)
 - Special Use Airspace (SUA)
 - Hazardous weather
- Detect differences in ETA and RTA
- Detect current position and velocity error from aircraft's flight plan

FD/ATSP Functional Requirements Summary

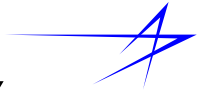
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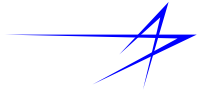
- Within the Look-Ahead Zone, resolve conflicts between aircraft and:
 - Other aircraft
(resolution based on both flight plan and predicted trajectory for all aircraft equipage levels)
 - Special Use Airspace (SUA)
 - Hazardous weather
- Allow for different resolutions based on RTA
- While within the Alert Zone, compute restricted zone between aircraft (done for conflicts) and:
 - Other aircraft (all equipage levels)
 - SUAs
 - Hazardous weather

FD/ATSP Functional Requirements Summary

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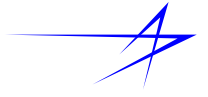


- Consider winds aloft data on aircraft performance
- Resolve conflicts during aircraft climb and descent (A/C conflicts only)



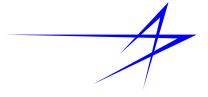
FD Functional Requirements Summary

- Modify existing flight plan/trajectory when accepted by user
- Weather and SUA information displayed on the FD display
- Provide an interface for accepting an ownship proposed flight plan
- Display proposed flight plans with a bold green dashed line if unable to meet an RTA requirement



ATSP Functional Requirements Summary

- Up-link trajectory restrictions to DEP aircraft
- Propose resolution OFP for each conflicting aircraft:
 - Resolution for all conflicts within Look Ahead Zone for all aircraft equipage types
- Weather and SUA information displayed on the ATSP display
- Display proposed flight plans with a bold dashed line if unable to meet an RTA requirement



Demo Features/Capabilities

- FD
 - Total Situation Awareness with Pilot Alerts
 - Reroute planning shows impact on RTA
 - Early conflict detection/decisions - minimal RTA impact & 4-D Route Planning
- ATSP
 - Total Situation Awareness of all aircraft
 - Efficient ATSP effort for all aircraft
 - ATSP active or passive with IND SAFFE capable A/C
 - Minimizes need for follow-up surveillance
 - Verbal contact only with Basic ADS-B A/C
 - Information can be shared with AOC
 - Tool automatically performs planning

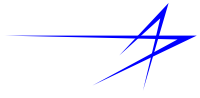
System Behaviors

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- Search for potential AZ conflicts within the LAZ (flight plan *and* trajectory)
 - PZs predicted to merge, a resolution advisory is calculated and presented to pilots to assure separation
 - PZs **not** predicted to merge, a restriction advisory is calculated and presented to pilots to maintain separation
 - Once accepted by pilots, resolution/restriction advisory is sent to controller and proximate aircraft for situation awareness
 - If controller does not receive advisory from FDs by the time the AZs merge, ATSP-SAFFE calculates resolution advisory to be issued to FDs
- Resolutions consider all FDs within LAZ to ensure that no new short-term conflict will be introduced

Display Functions and Outputs ^{A²T² RTO 5a}



Navigation Tools –

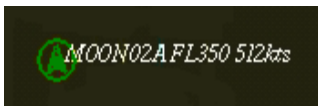
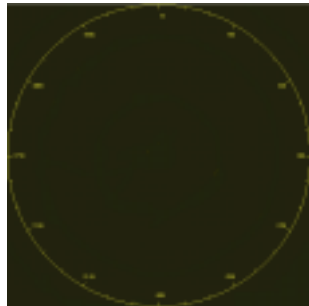
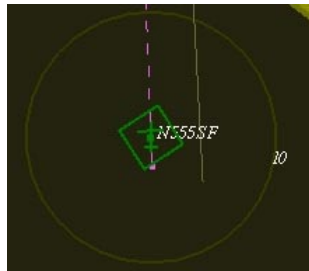
- Range Indicators – Brown circles with numeric nautical mile labels
- Bearing Indicator – Yellow circle with 30-degree compass indicators.

- Aircraft Data Blocks – White alphanumeric read-outs for::

- Aircraft call signs
- Flight levels
- Aircraft speed in knots
- Options – toggle between :
 - aircraft call sign
 - full alphanumeric read-out.

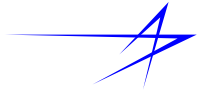
Simulation Clock –

- Yellow analog clock lower right hand corner



Display Functions and Outputs

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Navigation Advisories –:

Boundaries –

- Territory borders – solid white lines
- Coastal boundaries – solid blue lines
- Rivers – solid purple lines.



Winds Aloft –

- Vectors – solid brown lines
- Drawn for every degree (latitude and longitude).



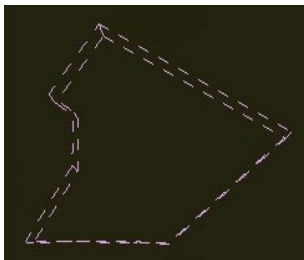
Weather Cells –

- Brown volumes.



Special Use Airspace (SUA) –

- Warning – transparent yellow volume
- Prohibited – transparent red volume



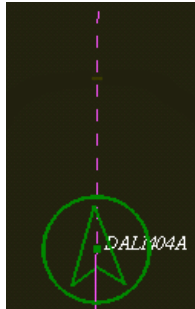
Air Traffic Sector Boundaries –

- Dashed purple lines outlining airspace



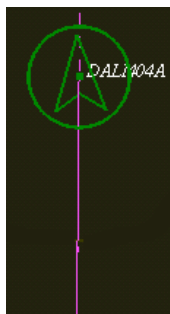
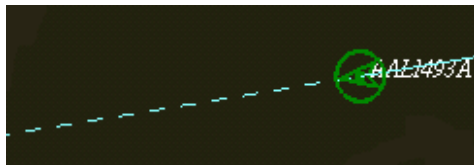
Display Functions and Outputs

Flight Paths – Flight path display descriptions are listed below:



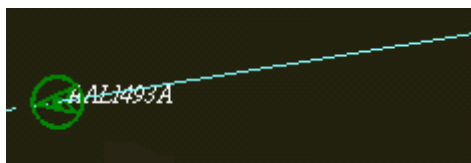
Filed and/or Accepted Flight Plans –

- Ownship – dashed magenta lines
- Other aircraft – dashed cyan lines
- ATSP – dashed cyan lines



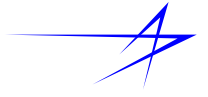
Flown or Traversed Flight Paths –

- Ownship – solid magenta lines
- Other aircraft – solid cyan lines
- ATSP – solid cyan lines

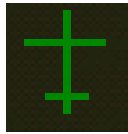


Display Functions and Outputs

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Aircraft Position Indicators



Aircraft Equipage Categories –

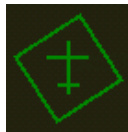
Basic Equipped Aircraft – straight-winged symbols.



Dependent Equipped Aircraft – swept-wing symbols



Independent Equipped Aircraft – chevron symbols



Aircraft Protected Zone –

Basic Equipped Aircraft – square surrounding straight-winged

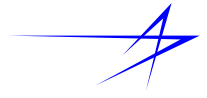


Dependent Equipped Aircraft – hexagon surrounding the swept-wing



Independent Equipped Aircraft – circle surrounding the

Display Functions and Outputs ^{A²T² RTO 5a}

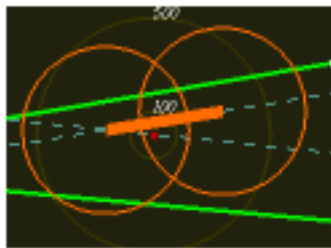


Conflict Advisories –

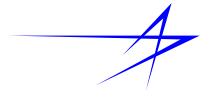
• Aircraft Position and Protected Zone Indicators



- No Conflict – green
- Conflict Outside the Alert Zone – yellow
- Conflict Inside the Alert Zone – red



Display Functions and Outputs ^{A²T² RTO 5a}



Resolution Advisories –

- **Proposed Routes and Proposed Future Waypoints**

–

- Proposed Routes Meeting Assigned RTA – bold solid line
- Proposed Routes Not Meeting Assigned RTA – bold dashed line

- **FD Displayed Routes –**

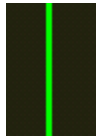
- **Independent FD Generated Routes –**

- Ownship generated routes – green.
- ATSP generated advisory routes – yellow
- Proposed waypoints – white blocks along proposed flight path.

- **Dependent FD Displayed Routes –**

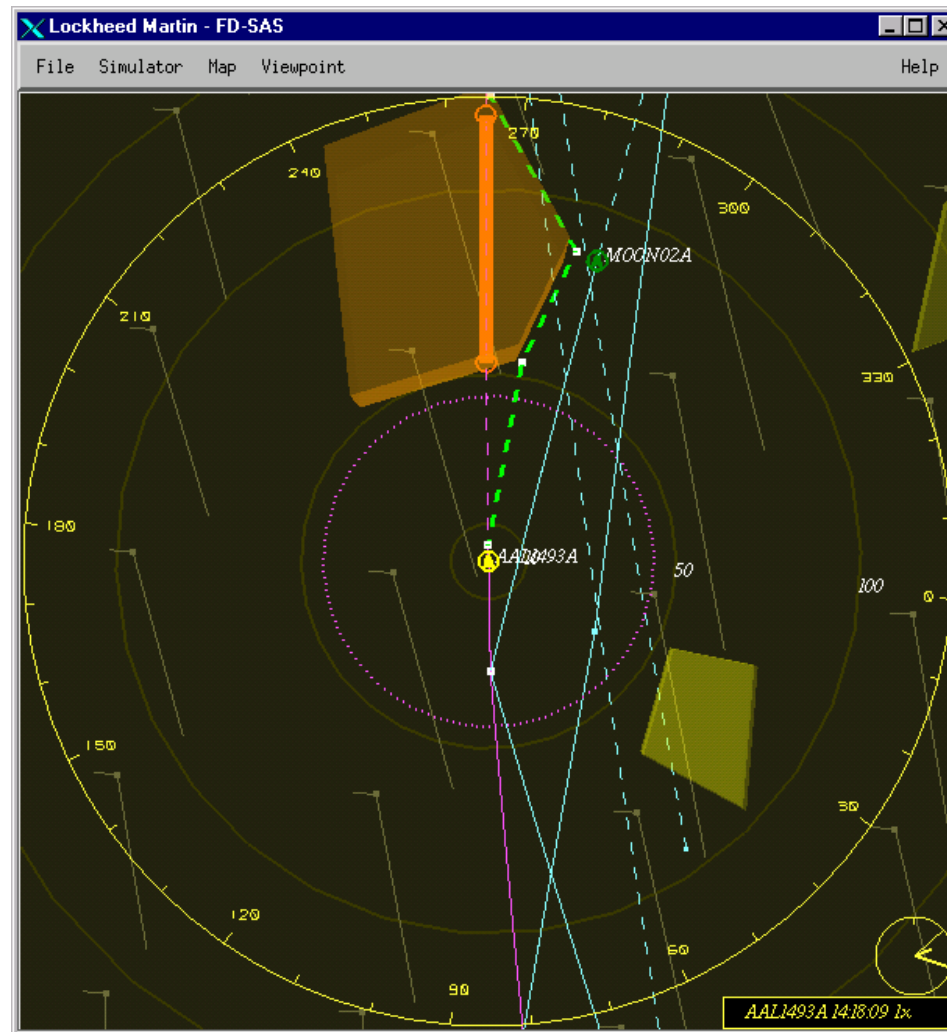
- ATSP generated advisory routes – yellow

– Proposed waypoints – white blocks along





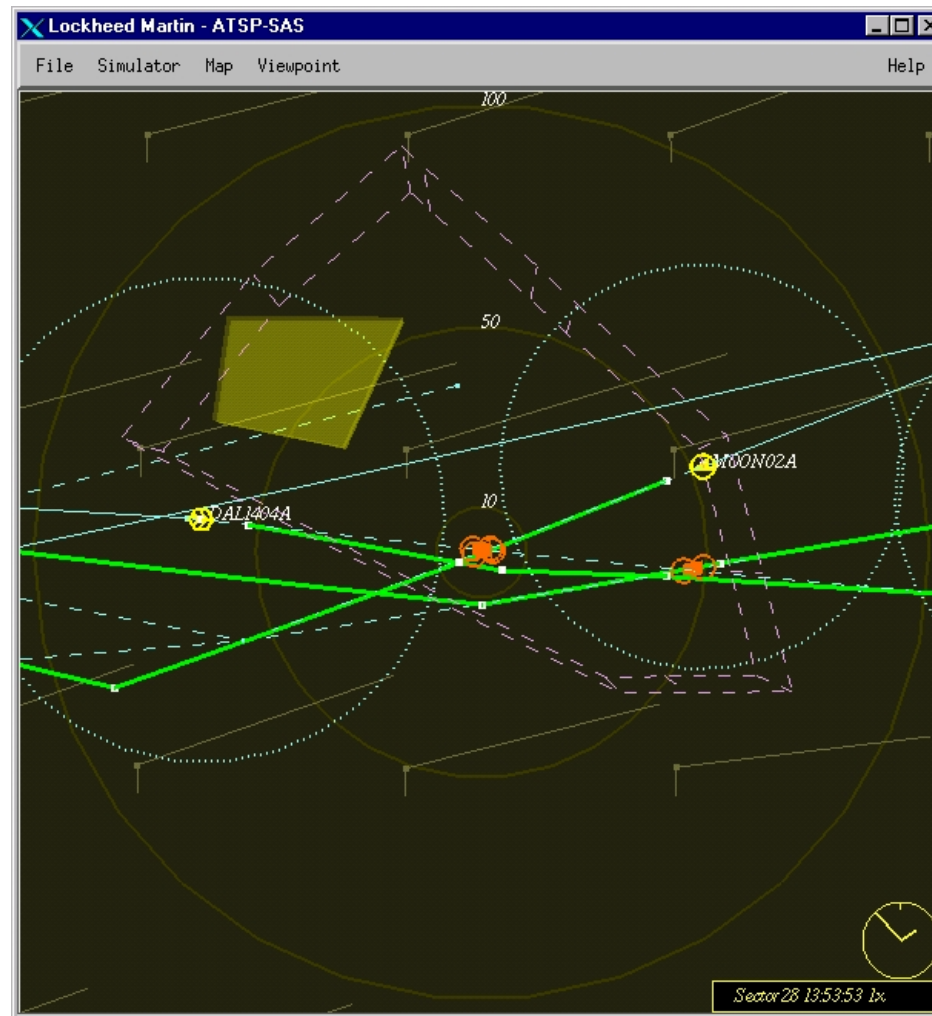
Cockpit Display Example



Independent Equipped Aircraft Display



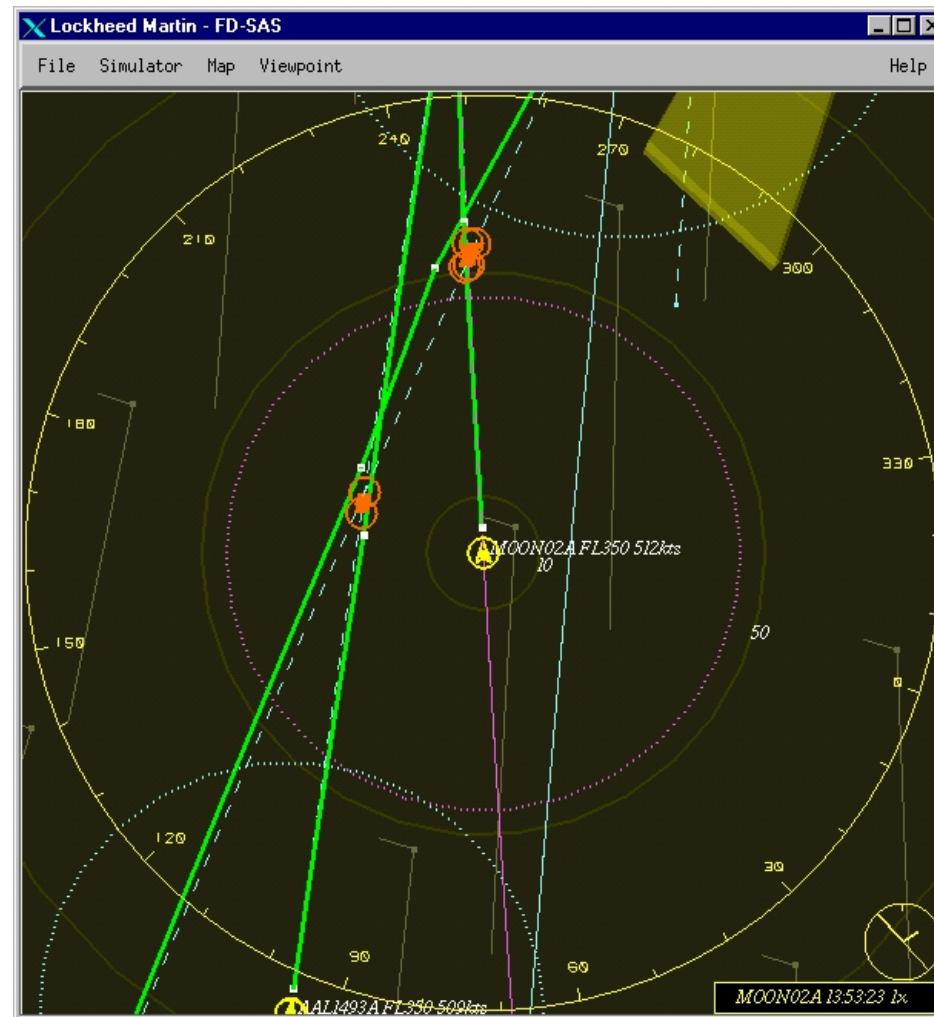
ATSP Display Example



Multiple Aircraft Conflicts Display



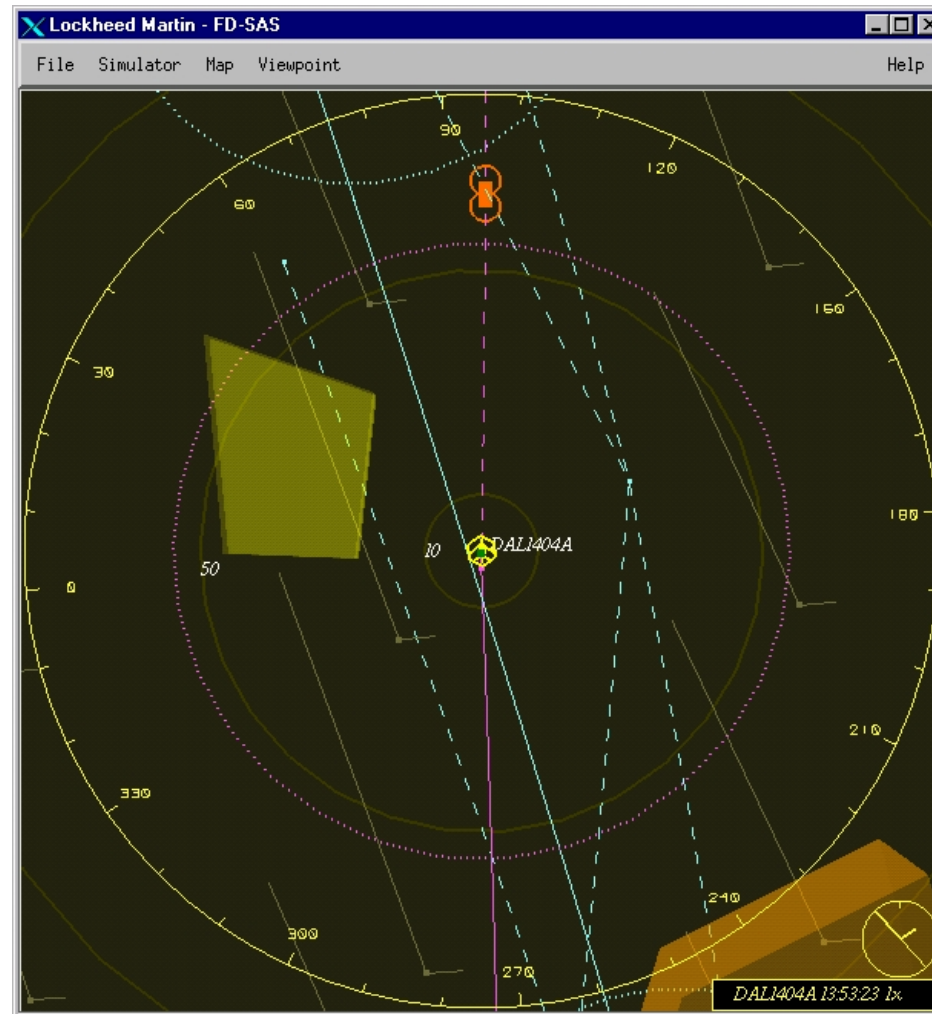
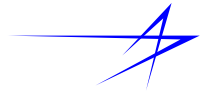
Cockpit Display Example



Multiple Aircraft Conflicts Display

Cockpit Display Example

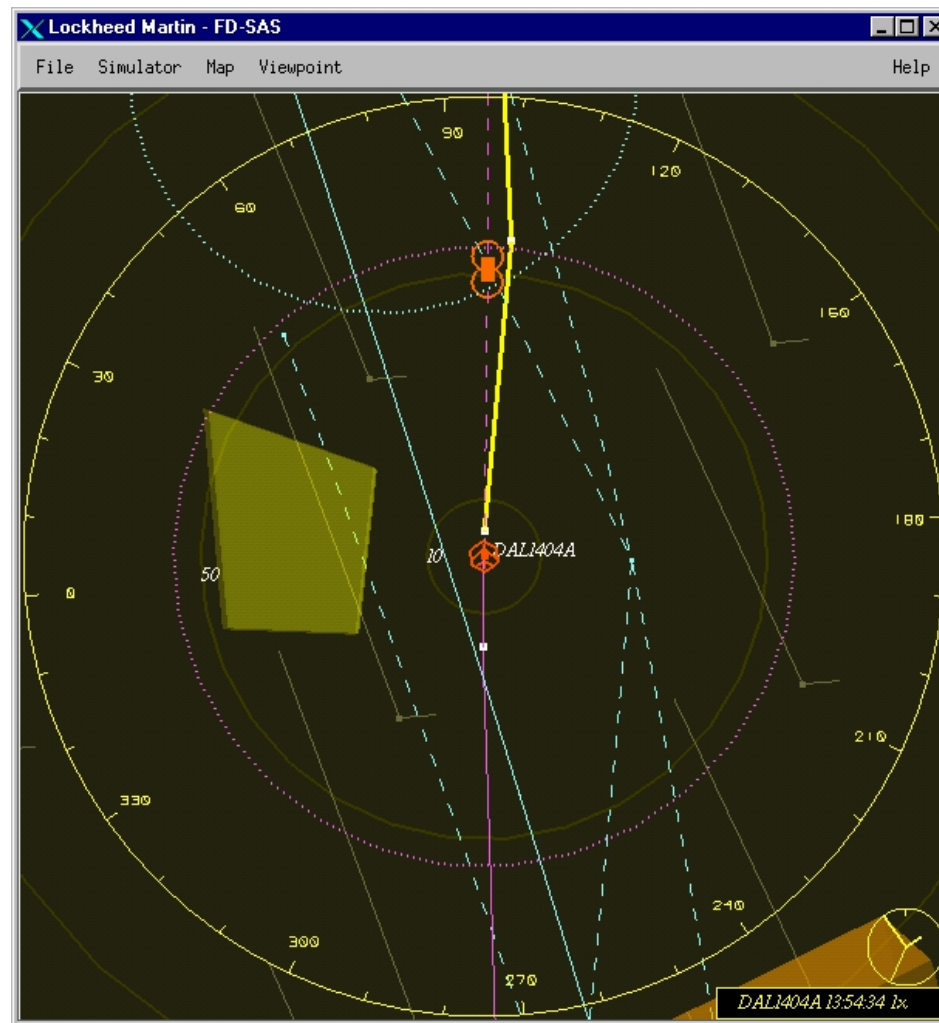
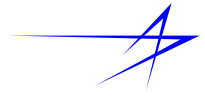
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Dependent FD with an ATSP Generated Conflict Advisory

Cockpit Display Example

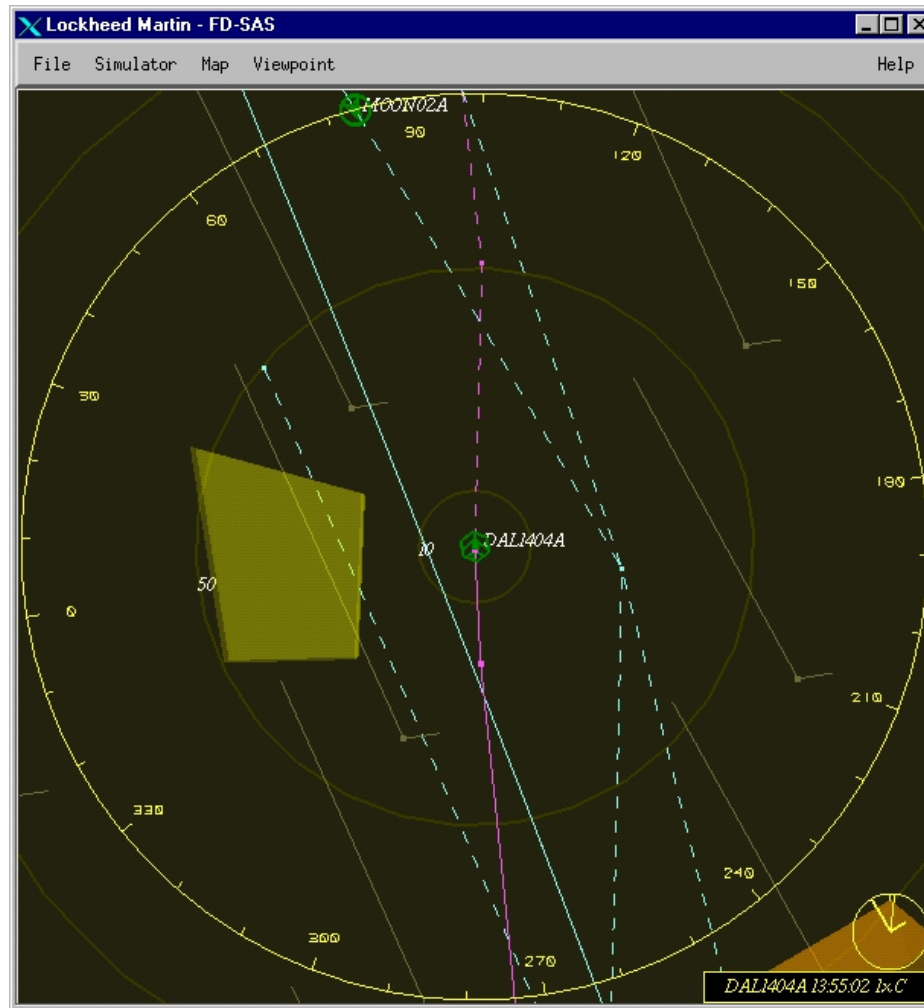
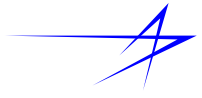
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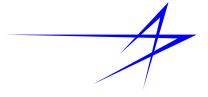
Dependent FD with an ATSP Generated Resolution Advisory

Cockpit Display Example

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Dependent FD Accepted ATSP Resolution Advisory



Demonstration Scenarios

- Five distinct scenarios presented:
 - *Scenario 1*
 - Mixed equipage conflict
 - ATSP provides resolution
 - *Scenario 2*
 - DEP/DEP aircraft conflict
 - Weather cell conflict
 - ATSP provides resolution
 - *Scenario 3*
 - IND/IND aircraft conflict
 - Aircraft resolve conflict
 - ATSP monitors situation

Demonstration Scenarios

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– Scenario 4

- IND/IND aircraft conflict with RTA considerations
- Merging of Alert zones
- ATSP resolves conflict when IND aircraft do nothing

– Scenario 5

- Same as Scenario 4, except one IND aircraft has failed equipment
- Aircraft with failure cannot accept route plan when requested by ATSP
- Other IND aircraft resolves conflict by ATSP direction